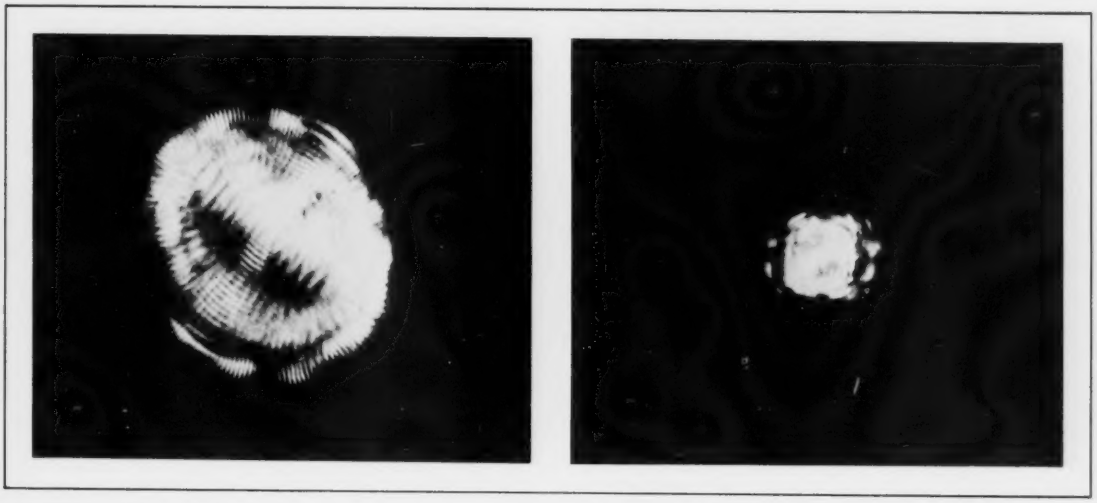
NATIONAL BUREAU OF STANDARDS *August/1969*

Technical News Bulletin



U.S. DEPARTMENT OF COMMERCE

Nat. Bur. Stand. (U.S.), Tech. News Bull
CODEN: NBSTA 53 (8) 169–192 (1969).

NATIONAL BUREAU OF STANDARDS

TNB Technical News Bulletin

AUGUST 1969/VOL. 53, NO. 8/ISSUED MONTHLY

U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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Extremely clear beam images of a neodymium laser rod show internal stresses produced during lasing activity. A near-field image appears at left; a far-field image at right. *(See page 180.)*

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

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The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $3; foreign, $4; single copy, 30 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 22, 1966).

Library of Congress Catalog Card Number: 25–26527

WEATHERING EFFECTS ON PLASTICS

G. E. Fullmer (left) and J. E. Clark examine a specimen of plastic that has been tested to rupture.

PREDICTION OF A PLASTIC'S WEATHERABILITY is the goal of a current study at the NBS Institute for Applied Technology. The study is being conducted by J. E. Clark and J. A. Slater, NBS Research Associates under sponsorship of the Manufacturing Chemists' Association, in cooperation with G. E. Fulmer of the W. R. Grace & Co., and R. C. Neuman of the B. F. Goodrich Chemical Co. Numerous appearance, physical, and fundamental properties of plastics are being examined in simulated and outdoor exposures.[1] This phase of the study deals with the changes in tensile and flexural properties resulting from outdoor exposure.

To date, measurements have been made on 20 plastics composed of 6 base polymers that were exposed for 24 months in Arizona, Florida, and Washington, D.C. The plastics include polyethylenes (PE), polymethyl methacrylates (PMMA), polyvinyl fluorides (PVF), polyethylene terephthalates (PETP), glass-reinforced polyesters (RP), and polyvinyl chlorides (PVC).

All 20 plastics were subjected to modified ASTM tensile tests. Five parameters were then obtained from the resulting stress-strain curves. These included Young's modulus of elasticity, yield stress, yield strain, failure stress, and ultimate elongation at break.

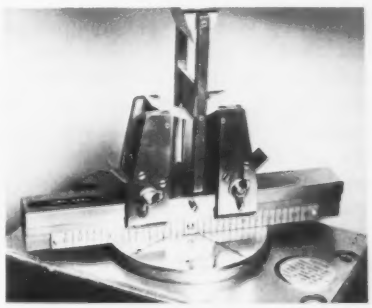
The flexural parameters measured were Young's modulus; yield stress; yield strain; rupture stress, rupture strain; and stress at 5 percent strain, if the material did not break at less than 5 percent strain.

The ultimate tensile elongation and 5 percent flexural stress showed the greatest change with time. Ultimate elongation decayed rapidly within one year for most of the plastics. Five percent stress increased substantially in a few months after which there was little or no change. An increase in 5 percent stress was usually accompanied by a decrease in ultimate elongation. These changes indicate a loss of elasticity and flexibility, resulting in increasing stiffness and probably brittleness.

Using ultimate elongation and 5 percent stress, percent retention of initial value was found to be a useful measure for classifying the plastics. Smooth curves fitted for the percent retention of initial ultimate elongation show a definite exponential decrease. Mathematical models using functions of time and weather variables are currently being fitted to the ultimate elongation data.

In general it was found that the plastics performed worst in Arizona, best in Washington, D.C., and intermediate in Florida. Actinic radiation and heat appear to be the primary agents causing physical degradation. Washington, D.C., exposed samples, however, sometimes exhibited a greater loss of physical properties than Florida exposed samples, possibly indicating effects of moisture and air pollution.

[1] Outdoor Performance of Plastics, Nat. Bur. Stand. (U.S.), Tech. News Bull. 53, No. 5, 108 (1969).



Flexural measurement being made on a specimen of plastic exposed to outdoor weathering conditions.

HEAT-PIPE OVEN GENERATES HOMOGENEOUS METAL VAPORS

Spectroscopic Measurements Facilitated

C. R. Vidal is shown with a heat-pipe oven (left) and spectrometer (right) that he uses in spectroscopy research.

A "HEAT-PIPE OVEN" HAS BEEN DEVISED that overcomes many faults of commonly used apparatus for generating homogeneous metal vapors.[1] The oven was developed by C. R. Vidal and J. Cooper of the NBS Radio Standards Physics Division at Boulder, Colo. It continuously generates a homogeneous vapor having a well-defined temperature, pressure, and optical path length. In addition, its unique features eliminate the reaction of the metal vapor with window materials.

The heat-pipe oven was primarily designed for spectroscopic applications. Because of its unique features, however, it may find applications in a number of other areas including metal-vapor plasma generation.

In many spectroscopic applications there is an important need to generate well-defined, homogeneous metal vapors of known density and temperature. To generate these vapors it is common practice to use furnaces, atomic beam devices, hot cathode diodes, burner systems, or other similar means. These, however, have their faults, even though considerable effort has been made to overcome them. One such fault is the failure to maintain a constant, homogeneous temperature and density distribution of the vapor for a sufficiently long period of time. In addition, even where the vapor does not react with the window material, the windows must be maintained at a temperature slightly higher than the rest of the system to prevent vapor condensing on the window, which makes it optically opaque.

Heat-Pipe Principle

The NBS-devised oven is based on the principle of the heat-conductive element called the heat pipe [2]—a device that transfers large amounts of heat by evaporating a liquid, transporting the vapor through a duct, and then condensing the vapor back to the liquid state. A heat pipe consists of a closed tube, the inner wall of which is covered by a capillary structure acting as a wick. This wick is saturated with a wetting liquid. At one end of the tube the liquid is heated by an external heat source causing the liquid to vaporize. A heat sink at the other end of the tube causes the vapor to condense. The condensate then returns through the wick by capillary forces to the heater section.

In this manner heat conductivities have been obtained that are orders of magnitude greater than the ordinary thermal conductivity through metal rods of comparable size. Furthermore, the heat pipe has been proven to operate in a gravity-free environment.

Oven Design

Essentially, the heat-pipe oven uses a tube in which the central portion is designed like a conventional heat pipe with a capillary structure of several layers of woven mesh on the inner wall. Both tube ends are closed by demountable units that connect the tube to a vacuum system and retain the optical windows. The tube is heated at its mid-

s tion by an induction heating coil. To prevent oxidation of the outer surface of the tube, it is surrounded by a vacuum chamber that is sealed against the tube by O-rings. The O-ring seals and the vacuum chamber are water cooled. The whole assembly is demountable, allowing the tube to be easily substituted by another tube without replacing any other part of the whole system.

The heat-pipe oven was first built for use with lithium, which has the desirable qualities of a very high heat of vaporization, a high surface tension, and a low density. The tube is made of stainless steel, which is compatible with lithium, and has a diameter of 2.5 cm and a wall thickness of 1 mm. The surrounding vacuum chamber is 34-cm long in which a 25-cm metal vapor section in the tube has been achieved. The vacuum chamber has an optical window along its side permitting temperature measurements of the tube wall using a pyrometer. A shutter placed inside this window substantially reduces sputtering from the outer surface of the tube to the window.

Operation

In operation, the heat-pipe tube contains an inert gas at a suitable pressure. The induction heater melts the metal, which wets the stainless steel mesh wick. Depending on the pressure of the inert gas, the metal at the heater section evaporates at a particular temperature, governed by the temperature-vapor pressure relationship for the metal. The metal's vapor pressure equals or just exceeds the inert gas pressure. This causes the metallic vapor to diffuse towards both ends of the tube where it condenses because of the slightly lower temperature at the tube ends. The condensate then returns through the wick to the heater section of the tube. This return is due to capillary action. Finally, an equilibrium is reached in which the center portion of the tube is filled with a metallic vapor at a pressure determined by the confining inert gas at both ends of the tube.

Because of the pumping action of the flowing vapor, the inert gas is completely separated from the vapor except for a short transition region whose thickness depends on the pressure, the type of vapor, and the inert gas. To keep this boundary layer sufficiently short, typical operating pressures of about 1 torr (1.33×10^2 N/m^2) and higher are used. The total length of the metal vapor section depends almost entirely on the induction heater power input and the confining inert gas pressure, which determines the vapor temperature. Although the heat-pipe oven is open at both ends, it is completely stable in operation without any measurable shift of the metal-vapor zone. At typical temperatures of about 600 °C and higher, power is predominantly removed by radiation from the tube wall. For this reason the surround vacuum chamber is water cooled.

The new heat-pipe oven features a number of significant advantages over previously used systems. The generated metal vapor, for example, is very clean because the continuous evaporation and condensation purifies the vapor.

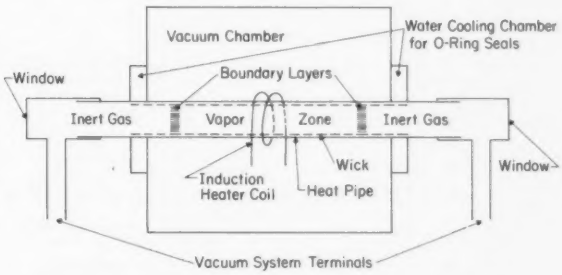
The inert gas volume between the optical windows and the vapor zone solves the "window problem," which, particularly at high temperatures, has been a serious problem for all highly reactive elements like barium, lithium, and a large number of other elements. The inert gas volume also solves radiative transfer problems that frequently arise because of poorly defined vapor zones.

A further advantage of the heat-pipe oven is that it can be continuously operated for long periods under well-known and well-controlled conditions. Since evaporation and condensation of the metal take place at almost the same temperature, the temperature of the vapor is constant to within 1 °C over the entire metal-vapor zone without using radiation shields or heat baffles. Only near the short boundary layers does the temperature drop rapidly. A suitable thermocouple easily detects the temperature of the metal-vapor section to a 1 °C accuracy.

The pressure of the metal vapor can be determined with great accuracy from a measurement of the confining inert gas pressure. Pressures of 1 torr (1.33×10^2 N/m^2) and higher are easily measured with a simple oil-type manometer to within 1 percent. There is a small pressure gradient within the vapor zone necessary to establish the vapor stream. However, a simple estimate of the necessary vapor flow for a particular power input shows that the change in pressure and the equivalent change in temperature are always negligible for any practical situation.

The heat-pipe oven has been used successfully in a number of spectroscopic measurements including a photoelectric scan of the lithium principal series 2^2S–n^2P, which has been observed up to principal quantum numbers of about $n=60$. Resonance fluorescence spectra of the Li_2 molecule have also been observed after excitation by various lines of the argon ion laser.

[1] Vidal, C. R., and Cooper, J., J. Appl. Phys. 40 (1969).
[2] Grover, G. M., Cotter, T. P., and Erickson, G. F., J. Appl. Phys. 35, 1990 (1964).

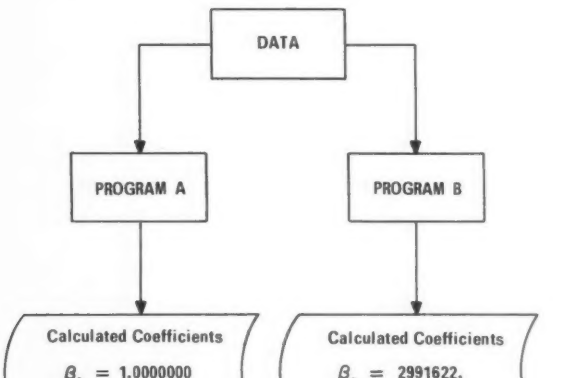


Schematic of the NBS-devised heat-pipe oven. In operation, the heater coil vaporizes a metal, which flows toward both ends of the oven. It is then condensed and returned through the wick to the heater area. Thus, a continuous generation of homogeneous metal vapor is obtained.

ASSESSING COMPUTER PROGRAMS

Solutions for Least Squares Problems Evaluated

THE NBS STATISTICAL ENGINEERING LABORATORY has studied the accuracy of computer programs for obtaining least squares representations of data and found that some of the most popular programs using naive matrix methods yield accuracy far inferior to those that use more sophisticated techniques.[1] Roy H. Wampler, of the Bureau's staff, evaluated 27 different computer programs by running two least squares test problems on each. Some programs, those based on mathematical algorithms using orthogonal transformations, orthonormalization, or orthogonal polynomials, yielded acceptable accuracy, whereas those based on elimination algorithms gave poor results, some totally unacceptable. The NBS evaluation should be useful to scientists in selecting suitable least squares programs.



Computer programs were evaluated for obtaining least squares fits by running sample problems on them. The coefficients for the formula, $Y=\beta_0+\beta_1X+\beta_2X^2+\beta_3X^3+\beta_4X^4+\beta_5X^5$, were calculated for the same data by two different programs. All of the coefficients should be 1.0; program A (orthonormalization method) yielded almost all perfect values and program B (elimination method) only highly erroneous ones, indicating the extremes of accuracy and inaccuracy discovered in the evaluation.

Least Squares Programs

Mathematicians and scientists faced with the task of finding a curve to represent a collection of values in two or more variables often obtain such a curve by the method of least squares. The solution is an equation for which the sum of the squared deviations of the data from the curve is smallest. This can be found by use of a desk calculator, but since the advent of the electronic computer many computer programs have been written for this purpose. The computational procedures suitable for desk calculators are often quite unsuitable for computers.

The computer programs obtain the least squares fit by using one of several basic computational schemes, called algorithms. Because least squares problems are often ill-conditioned—have data points in configurations difficult to deal with—the algorithm used can affect the accuracy of the solution. An evaluation of programs was needed to enable users to select good programs for solving such problems.

Programs and Computers Used

The present study was undertaken to assess the numerical accuracy of representative least squares programs from a variety of sources. Many of them are subroutines in widely used computer systems and programs, which can be turned to like recipes in a cookbook. Included in the study were least squares programs from the University of California (Los Angeles) Biomedical Computer Programs collection, the C-E-I-R Multi-Access Computing Services library, the IBM SHARE library and System-360 Scientific Subroutine Package, the Univac MATH-PACK and STAT-PACK collections, and the Massachusetts Institute of Technology's Project MAC 7094 disk files.

The programs studied used essentially four different algorithms: orthogonal Householder transformations, Gram-Schmidt orthonormalization, orthogonal polynomials, and Gaussian or Jordan elimination.

Four computers were used: a Univac 1108 located at the Bureau's Gaithersburg, Md., laboratory complex, an IBM 7094 at the Army's Harry Diamond Laboratories in

Washington, D.C. (as well as one at MIT, Cambridge, Mass.), a time-shared GE 235 located at Bethesda, Md., and a Univac 1107 in Washington, D.C.

The Test Problems

The two test problems used in the least squares study, both fifth degree polynomials with 21 data points, were chosen to be so highly ill-conditioned that some of the programs failed to give acceptable solutions. Other programs, however, succeeded in obtaining accurate results. For some programs, both single precision and double precision versions were used in running the problems. Polynomial problems were chosen because this type of least squares problem is common in practice.

Findings

Comparison of the coefficients reported from the computer runs disclosed that programs using orthogonal Householder transformations and Gram-Schmidt orthonormalization were much more accurate than those using elimination algorithms. The most successful programs were those that accumulated inner products in double precision and used iterative numerical refinement procedures. One of the best programs was ORTHO, written in 1954 by NBS mathematicians who pioneered in computational procedures for high-speed computers.[2]

Least squares programs have been appraised in the past; Mr. Wampler's contribution is to report on a widened variety of them. They were selected from among those that are most accessible and hence include the ones from which most users make their selection.

[1] Wampler, R. H., **An evaluation of linear least squares computer programs**, J. Res. Nat. Bur. Stand. (U.S.), **73B2**, 59 (Apr.–June 1969).

[2] Davis, P., and Rabinowitz, P., **A multiple purpose orthonormalizing code and its uses**, J. Assn. Computing Machinery **1**, 183–191 (1954). See also, Davis, P. J., **Orthonormalizing codes in numerical analysis**, Ch. 10 in "Survey of Numerical Analysis," edited by J. Todd (McGraw-Hill Book Co., New York, N.Y., 1962); and Walsh, P. J., **Algorithm 127, ORTHO**, Comm. ACM **5**, 511–513 (1962).

COMPUTER SIMULATION OF BUILDING FIRES

An Important Part of Fire Protection engineering is predicting the probable course of a building fire from its ignition to its extinguishment. It is anticipated that accurate predictions would lead to much valuable data for a better understanding of the physics of a fire and improved fire suppression activity.

A recent study at the NBS Institute for Applied Technology has explored the feasibility of simulating a building fire using a computer.[1] This work, by J. A. Rockett, an NBS Research Associate sponsored by the Factory Mutual Engineering Corporation, has also indicated areas where further fire research is needed.

In the NBS simulation, a building is divided into cubicles (a single-family house would consist of about 44 cubicles). Data on the amount and type of combustible material at a particular location and the effects of a fire at one location on all other locations accessible to it are included. Air movements are calculated and the geometric features affecting air movements are compiled. Sprinkler system details are included if appropriate to the particular building under study.

A fire is described as being in one of a number of different states such as: out, no fuel available; out, but fuel available; ignited, too small to ignite an adjacent cubicle: and established fire, able to cause adjacent ignitions.

The NBS computer prorgam that followed the course of a fire for a particular building of 437 cubicles contained 2078 words of program instruction. In this case, 48 seconds on the computer followed the fire in 1-minute steps for 7 minutes as it spread through 17 cubicles opening 4 sprinkler heads. The very rapid spread of fire in this particular example is accounted for by the office building chosen, and the very high combustibility assumed for its contents.

The calculation included "assembling" the building from basic data and installing the sprinkler system from standard design rules. The method can be adapted for a wide range of situations by modifying the basic program.

One of the more troublesome parts of the analysis is the representation of air movements in the building. A calculation of the air movement involves the two problems of input data and computing time. Although the geometry of the building is easily managed, it is altered by the doors and windows whose positions (open or closed) are generally not known. This obviously affects the movement of air and, in turn, the course of the fire.

At this time it is not possible to make precise predictions of building fires from an analysis of the building-fire system. However, the feasibility of such predictions appears quite promising. As more data on fire loads and air movements become available, better simulations will be possible. This should result in extremely valuable data for applications in fire protection engineering.

[1] Rockett, J. A., **The objectives and pitfalls in the simulation of building fires with a computer**, Fire Technology (in press).

HAIL RESISTANCE OF ROOFING

ACCORDING TO WEATHER BUREAU RECORDS, hail produces a greater annual building loss than does the more spectacular tornado.

Storms containing hailstones in the size range from 1½ to 3 inches in diameter are fairly common in the area between the Appalachian and Rocky Mountains. While there is no evidence that the number of such storms has been increasing in recent years, the population has grown in that part of the country. This has resulted in more buildings and, consequently, the incidence of building damage from hail has increased.

In an effort to reduce roof damage from hail, a test procedure has been devised at the NBS Institute for Applied Technology for evaluating the hail-resistance performance of roofing products. The work was done by S. H. Greenfeld, NBS Research Associate, sponsored by the Asphalt Roofing Manufacturers Association.[1] By use of this procedure, numerous types of roofing products have been subjected to simulated hail conditions. It is hoped that such studies will lead to improved methods and materials for roofing and, as a result, decrease building damage.

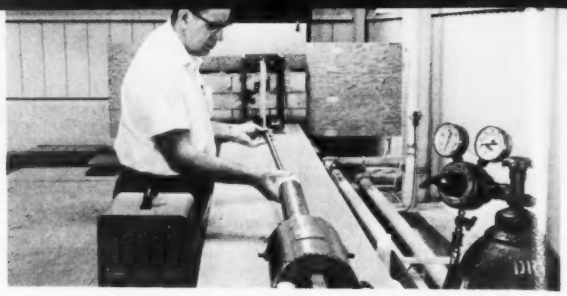
Test Apparatus

The testing apparatus used in the study consisted of a compressed-air gun to launch the hailstones, a timer to determine their velocity, and a target holder for positioning the specimen. The compressed-air gun was a commercially available device with a 3¼-in barrel (inside diameter) and a controllable muzzle velocity of up to 300 ft/s.

To use the gun for different sized hailstones it was necessary to launch them in carriers. The carriers were made from 3-in diameter foamed-polyethylene cylinders, which were cut longitudinally into hemicylinders. Each hemicylinder was truncated at one end, at a 45° angle to its long axis, from the central cut to its outer wall. It was then milled with one of a series of hemisphere sizes, representing the hailstone sizes to be carried, centered 2¼ in from its other end.

When the pairs of hemicylinders were reassembled they formed carriers for the several sizes of hailstones, which had been frozen in molds. When the carrier containing a hailstone was propelled out of the gun, air resistance caused it to open, thus permitting the hailstone to travel alone. Progressively larger stones were fired at a material until failure occurred.

To determine the speed of the hailstones, a timing device was used in which two 1-in paper tapes were fastened to microswitches under sufficient tension to close the switches upon any impact. As a hailstone hit the first tape it closed the switch starting a counter. After traveling 2 feet farther it hit the second tape, which stopped the counter. The speeds and energies of the hailstones averaged over the 2 feet immediately in front of the specimen could thus be calculated and recorded.



L. F. Skoda loads a compressed-air gun with a hailstone, enclosed in a holder, prior to launching. Hailstones fired at the roofing specimen (background) strike the two paper tapes in front of the specimen, which start and stop a counter (lower left) to determine their velocity.

Types of Roofing

Various types of roofings were evaluated during the study. These included asphalt shingles with various backing materials, built-up roofing systems, and nonbituminous roofings.

The built-up roofs consisted of alternate layers of bitumen and reinforcing membranes. Some of the roofs were surfaced with a smooth layer of bitumen and others with a layer of pebbles, crushed stone, or lightweight-aggregate particles.

A number of nonbituminous roofings were also tested for comparison purposes. These were prepared in accordance with their suppliers' recommendations.

Brittle roofings were considered to fail when they cracked; metal roofings were considered to fail when objectionable indentations occurred.

Results

As the size of the hail is increased, obviously a level of impact energy must eventually be reached at which damage occurs. It was found that this level lies in the area of 1½- to 2-in hailstones for most prepared roofings. Other results of the study include the following: (1) Because of the ways in which prepared roofings are applied, most roof products have areas of different vulnerability. (2) The solidly supported areas of roofing tend to be the most resistant to hail damage. (3) Heavy-duty asphalt shingles tend to be more hail resistant than lighter types. (4) Weathering tends to lower the hail resistance of asphalt shingles. (5) Built-up roofs on dense substrates tend to resist hail better than those on soft substrates. (6) Built-up roofs made with inorganic felts tend to be more hail resistant than those of organic felts. (7) Coarse aggregate surfacing tends to increase hail resistance of roofing.

[1] Greenfeld, S. H., Hail Resistance of Roofing Products, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. (in press).

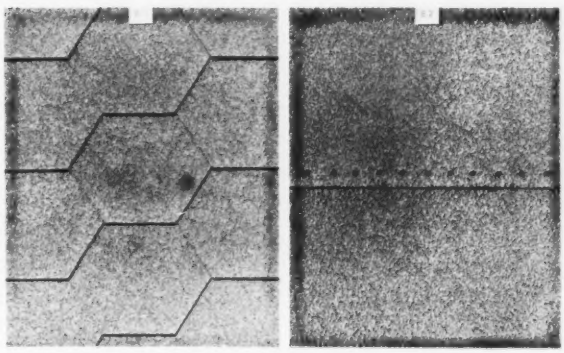
ASPLUND FELT ROOFING PERFORMANCE

SHORTLY AFTER THE BEGINNING OF WORLD WAR II, the combination of increased construction, decreased supply of rags, and introduction of the Asplund method of defibrating wood resulted in the fabrication of felt roofings with a portion of the rags and paper replaced by wood. This brought with it a need for an unbiased evaluation of the long-term effects that wood fibers might have on the durability of the roofings.

A program [1] to evaluate the performance of this type of roofing was initiated at NBS in 1942 under a Research Associate plan sponsored by the Asphalt Roofing Manufacturers Association. The study was designed to evaluate roofings with hard- and soft-wood fibers in concentrations of up to 60 percent of the dry felt weight. The effects of heat and chemical treatment of the fibers were also studied. Twenty-five years of exposure have shown that durable shingles and mineral-surfaced roofing can be made from organic felts regardless of the type or quantity of Asplund fibers used.

Thirteen different compositions of felts were used in the study. A control group contained no Asplund fibers. The others ranged from 15 to 60 percent wood. Of these some were heat treated and others were chemically treated by the addition of caustic soda (NaOH) during the defibration process.

The felts were made in a commercial felt mill, saturated in a commercial saturator, and made into finished products on a commercial roofing machine. Conditions of operation, saturants, coatings, and granules were kept as nearly uniform as possible. The physical characteristics of the saturated felts with which the roll roofings and shingles were made met or exceeded the minimum saturation and strength requirements of ASTM and Federal specifications.



Composed of various amounts of Asplund wood fibers, these shingles and roll roofing withstood outdoor weathering conditions for 25 years.

The specimens were exposed on specially constructed roof decks, which were erected on top of a building at the NBS site in Washington, D.C. The decks faced south and were inclined at a 45° angle.

Members of the Research Committee of the Asphalt Roofing Manufacturers Association and representatives of NBS inspected the specimens in 1948, 1954, 1958, and 1965.

After 6 years of exposure, the shingles were performing better than the mineral-surfaced roll roofings. A small amount of blistering was becoming apparent on the roll roofing, but not on the shingles. Weathering, however, had not progressed far enough to evaluate the deterioration resulting from differences in felt composition.

No consistent pattern of deterioration relating to felt composition was detected after 12 years.

After 16 years of exposure, the opinion of the inspection team was that only one composition of felt had produced a mineral-surfaced roll roofing product that had performed less satisfactorily than the control. This composition contained the highest concentration (30 percent) of unmodified pine Asplund fibers. The chemically treated pine and unmodified oak fibers, however, were outperforming the control. All of the shingles were still performing extremely well, and all but four were rated excellent by all of the inspectors.

All of the mineral-surfaced roll roofings showed some signs of deterioration after 23 years, but all were still performing satisfactorily; none was considered a failure. Nine of the 12 Asplund felts were outperforming the control.

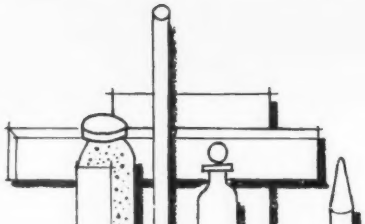
All of the shingle specimens were performing excellently after 23 years exposure. Only one specimen was performing appreciably worse than the control.

No group inspection was made after 25 years of exposure, but photographs were taken of all of the specimens. Examination of the photographs revealed that little change had occurred in any of the specimens since the 23-year exposure inspection.

After 25 years of exposure, it was concluded that all of the specimens had given a more-than-satisfactory performance. This clearly indicates that durable shingles and mineral-surfaced roofing can be made from organic felts regardless of the type or quantity of Asplund fibers used.

[1] Greenfeld, S. H., The Performance of Roofing Made With Asplund Felts, Nat. Bur. Stand. (U.S.), Tech. Note 477, 25 pages (Mar. 1969).

STANDARD REFERENCE MATERIALS



Standard Reference Materials are well-characterized materials certified for chemical composition or for a particular physical or chemical property. These materials [1] are disseminated by NBS to be used to calibrate and evaluate measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base.

DIELECTRIC CONSTANT STANDARD

The dielectric constant of most materials is commonly defined and measured as the ratio of the capacitance of a capacitor immersed in the medium in question to its capacitance in vacuum. Because most test capacitors (cells) are non-ideal, they must be calibrated for accurate work using air and one or more materials of known dielectric constant.

The NBS Office of Standard Reference Materials now offers Standard Reference Material 1511, Cyclohexane, as the first of three liquids to be certified for dielectric constant. The dielectric constant, ϵ, of this material was measured from 10 to 40 °C. Values obtained, relative to vacuum, on representative bottle samples were:

20 °C: 2.022 80±0.000 04
25 °C: 2.015 17±0.000 04
30 °C: 2.007 33±0.000 04

The uncertainties listed present the maximum deviation of observed values from the mean. At 30 °C, the standard deviation of the mean of 11 measurements was 0.000 028 units. Using the derivative $d\epsilon/dt = -0.001\ 54/°C$, relative values may be calculated from 10 to 40 °C without introducing significant errors. Based upon a summation of the probable uncertainties due to known sources of error in the measurements, the values of ϵ listed above are estimated to be accurate to ±0.02 percent or better.

The cyclohexane used for preparing SRM 1511 was obtained from Distillation Products Industries, Rochester, N.Y. It meets the American Chemical Society specifications for cyclohexane suitable for use in ultraviolet spectroscopy. It is not purported to be a standard of purity and is not free of traces of water. The research leading to the development of this standard was performed by C. G. Malmberg and M. G. Broadhurst of the NBS Polymers Division.

SRM 1511 is expected to be useful for the determination of the geometric capacitance of two terminal dielectric constant cells and for checking the linearity of the geometric capacitance of the three terminal (absolute) cells used for determination of dielectric constants. Standard Reference Material 1511, Cyclohexane for the Determination of Dielectric Constant, will be sold in units of 1 pint for $125 per unit.[2]

GOLD–COPPER WIRE MICROPROBE STANDARDS

A set of six gold-copper wires designed for use in quantitative elemental microprobe analysis has been made available as Standard Reference Material 482. Although this particular alloy system was selected on the basis of requirements of standard reference materials for electron probe microanalysis, the alloys are expected to be equally useful for other microtechniques.

These alloys are certified for chemical composition and homogeneity, and available as a set of six wires 0.5 mm in diameter by 5 cm long that are color coded to identify the individual compositions. SRM 482 is sold as a set for $130.[2] This set complements SRM 481, the set of gold-silver wires issued previously.[3]

The compositions of the alloys for SRM 482 were chosen especially for direct calibration of the electron probe microanalyzer for the gold-copper system and for testing theories of correction calculations for electron probe microanalysis. Because of the high homogeneity and well-determined composition, the standards will also be useful for other methods of microanalysis including laser-probe and optical-emission spectrometry and spark-source mass spectrometry.

Standard reference materials for microanalytical methods must have well-determined composition, and must be homogeneous at the microscopic level on which the analysis is performed. This set of standard reference materials now offered by NBS is the result of a 2-year program, including investigation of the compositions needed for the standards, their careful preparation, and their characterization. The materials were prepared by Cominco American, Inc., and chemical analyses of the wires were made by NBS, the U.S. Bureau of the Mint, and Cominco American, Inc.

The pure metal standards were examined by the residual resistance ratio technique and the total of electrically active impurities in each was estimated to be about 0.001 percent. The final standards were examined spectrographically for metallic impurities; no significant impurities were found.

Variation in composition along the full length of each alloy wire was investigated by electron probe microanalysis, using a specially designed automatic data collection system, for areas 25 μm in diameter at the two ends and at the center.

Homogeneity along the wires was also tested by measurement of the residual resistance ratio. These measurements indicated that the (macroscopic) variation of composition along all standard wires did not exceed 0.2 percent.

Variation in composition with the cross section of the wires at the three positions along the wire was also investigated by electron probe microanalysis. For each cross section, measurements were made along two diagonals at right angles. On each diagonal, determinations were made at 25 points, 1 μm or less in diameter, starting and ending at approximately 25 μm from the edge.

The homogeneity on a microscopic scale was further investigated by performing quantitative measurements in two-dimensional arrays of 10 x 10 points on each of the three cross sections. The distance between adacent points was 3.5 μm. This was repeated for three cross sections so that six arrays were obtained on each alloy.

PLUTONIUM SULFATE ASSAY

SRM 944, plutonium sulfate tetrahydrate, contains 47.50 percent of plutonium, and provides a secondary standard for the assay of plutonium materials. This standard supplements SRM 949b, plutonium metal.

Because of the stringent requirements for handling plutonium metal, SRM 944 should prove to be particularly attractive for assay work requiring an accuracy of the order of 0.1 percent. For assays not requiring the use of the entire standard, appropriate-sized subsamples of SRM 944 may easily be removed and weighed.

SRM 944 is relatively insensitive to humidity at room temperature over the range from 0–90 percent relative humidity. Each unit of SRM 944 contains the equivalent of 0.5 g of plutonium, and is priced at $65 per unit.

REVISED SRM PRICE SCHEDULE

On July 1, 1969, a new price schedule for Standard Reference Materials (SRM's) went into effect. This schedule raises the prices of all SRM's by $5 per sales unit. All orders shipped on or after July 1, 1969, reflect the new prices.

In the general repricing of NBS Standard Reference Materials (SRM's) contained in the 1968 edition of NBS Misc. Publ. 260,[1] it was anticipated that the new plan of pricing and organization of the SRM program would be effective for the indefinite future. It was indicated at that time, however, that minor adjustments in price might be necessary at the end of each fiscal year when the total costs of the SRM Program at NBS could be reevaluated. The reevaluation for fiscal year 1969 dictates the current price revision.

[1] For a complete list of Standard Reference Materials available from NBS, see **Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards**, NBS Misc. Publ. 260 (1968 ed.) for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which update Misc. Publ. 260 supplied to users on request.

[2] These standards may be purchased for the price indicated from the Office of Standard Reference Materials, Rm. B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

[3] **Standard Reference Materials**, Nat. Bur. Stand. (U.S.), Tech. News Bull. **53**, No. 1, 19–20 (Jan. 1969).

STANDARDS AND CALIBRATION

STANDARD FREQUENCY AND TIME BROADCASTS

High-frequency radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast time signals on the Coordinated Universal Time (UTC) system as coordinated by the Bureau International de l'Heure (BIH), Paris, France. These NBS time signals, UTC (NBS), are maintained within 5 microseconds of the corresponding time signals of the U.S. Naval Observatory, UTC(USNO). The UTC pulses occur at intervals that are longer than one coordinate second by 300 parts in 10^{10} during 1969, due to an offset in carrier frequency coordinated by BIH. To maintain the UTC scales in close agreement with the astronomers' time, UT2, phase adjustments are made at 0000 hours Greenwich Mean Time (GMT) on the first day of a month as announced by BIH. *There will be no adjustment made on September 1, 1969.*

The low-frequency radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses without offset to make available to users the standard of frequency so that absolute frequency comparisons may be made directly, following the Stepped Atomic Time (SAT) system. Step time adjustments of 200 ms are made at 0000 hours GMT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be an adjustment made on September 1, 1969. The seconds pulses emitted from WWVB will be retarded 200 ms.*

NBS obtains daily UT2 information from forecasts of extrapolated UT2 clock readings provided by the U.S. Naval Observatory with whom NBS maintains close cooperation.

Merritt M. Birky alines apparatus used to study internal stresses in laser rods.

INTERNAL STRESSES IN LASER RODS

Photographic Technique Developed

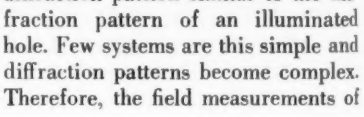
ONE OF THE PROBLEMS IN THE DEVELOPMENT of high quality lasers has been the internal stresses (rod distortion) caused by the rod material's thermal absorption of some of the induced pump radiation. Distortion of the rod reduces beam coherence and increases beam divergence of the laser light.

A scientist at the Bureau has been investigating the optical quality of solid state laser rods whose usage extends to scientific and industrial research. Merritt M. Birky of the NBS Institute for Basic Standards has developed a technique [1] for studying the effects of internal stresses and doping concentrations in laser rods during lasing activity. The work has been partially supported by the Advanced Research Projects Agency through Project DEFENDER.

The optical quality of solid state lasers can be studied by looking at both the passive (non-lasing) and the active (lasing) characteristics of the laser rod. Such passive tests as interferometric measurements determine the homogeneity of the optical path. However, the characteristics of the radiation output of the laser, such as coherence, beam divergence, and power capability are the important parameters; and a rod that appears to have good optical quality, as determined from passive tests, may not maintain this quality when subjected to the intense radiation of the pump source. Distortion caused by the pump radiation results in thermal gradients, index changes, and thermally induced birefringence.

To study the active quality of the laser rod, Dr. Birky has devised a method for simultaneously recording both the intensity variation of laser radiation observed near the output end of the laser (near-field) and the intensity variation of laser radiation of the rod when observed at infinity (far-field), during lasing activity.

For a reasonably good laser operated at low power, the near-field appears as a uniform intensity pattern and the far-field will show a simple diffraction pattern similar to the diffraction pattern of an illuminated hole. Few systems are this simple and diffraction patterns become complex. Therefore, the field measurements of



Simultaneous recording of near- and far-field images of a neodymium laser rod. Multiple near-field patterns, a, b, and c, correspond to multiple far-field patterns, d, e, and f.

ıe rods give indications of the types, mounts, and degrees of variation of od parameters, and may ultimately ead to a reanalysis of rod construc- ion in hopes to eliminate the distor- ion problem.

A near-field image pattern could be obtained close to the rod. However, an exact replica of the image of the end of the rod can be reproduced by using a lens and recording this image on a photosensitive material. The method described here enables an additional image to be recorded which corresponds to that obtained at infinity (far-field image). By placing a photographic plate in the focal plane of the lens, one can see what the focused beam would look like if allowed to travel to infinity. However, to be able to form any images, the high intensity of the beam must be greatly reduced in order not to burn the film, and to see contrasting patterns should there be any discontinuities in the rods.

Attenuation of the beam is accomplished in gradual steps by shining the incident laser light into a long rectangular prism at an angle to the prism surface that is less than 90 degrees. The light is both reflected and transmitted as it passes back and forth between two highly polished long sides of the prism. Only part of the light is transmitted at each air-crystal interface; thus the intensity is greatly reduced. Because light is transmitted at each reflection point of the two planes, two sets of images (near- and far-field) can be formed simultaneously if the separation between the laser and the lens is properly chosen. If f represents the focal length of the lens, then the minimum separation necessary for simultaneously recording near- and far-field patterns is $2f$. In this case the near-field image (or image of the output of the laser rod) appears at $2f$. And the far-field will appear at $1f$.

Results

Diffraction patterns, recorded on photographic film, enable the scientist to identify certain irregularities in the rod. These irregularities include inhomogeneities in material structure created during crystal production, intensity variations possibly caused by variation in doping concentrations, and changes in the length of the rod due to absorption of pumping radiation. This length change is not uniform across the rod, resulting in thermal stresses and possible fracture.

Shadowgrams and interferograms of the rods also showed the core regions observed by the new technique. Mathematical analyses are helping to explain more of these complex active laser characteristics.

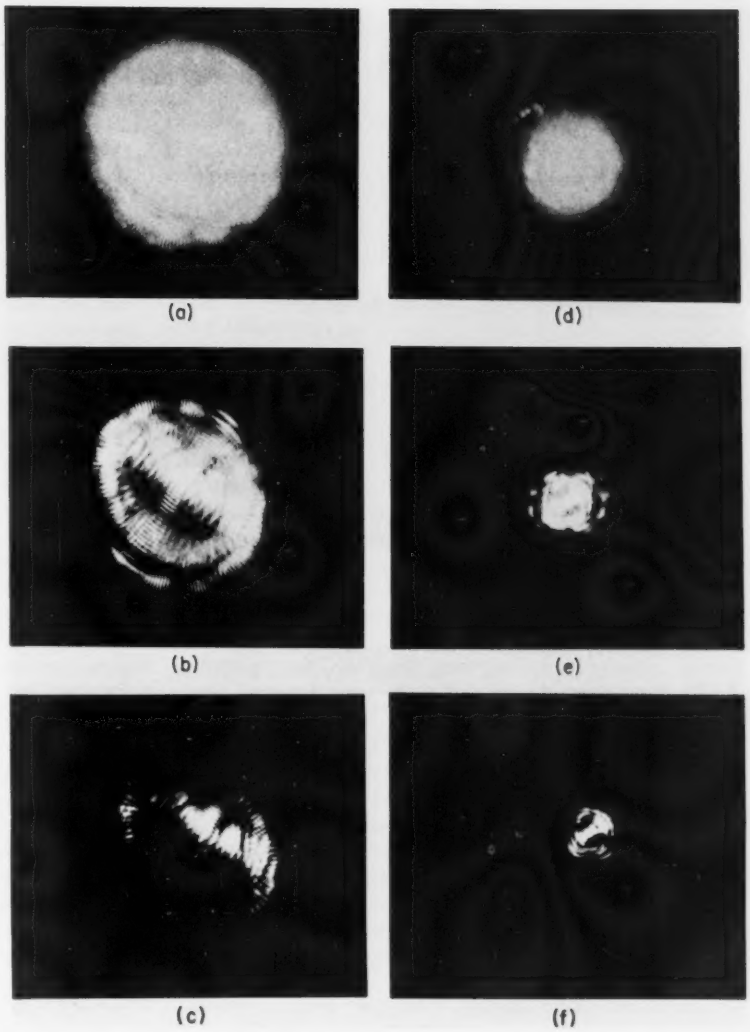


Diagram of apparatus used to record near- and far-field images of the ends of laser rods. Filter (F) and two stops (S_1 and S_2) remove flash lamp radiation. The laser beam is focused by lens (f), and finally attenuated in steps by the prism (P). The two sets of attenuated light pulses transmitted by prism are recorded on films—near-field pattern 2f, and far-field pattern 1f.

[1] Birky, M. M., Simultaneous recording of near-field and far-field patterns of optical masers, Appl. Opt. (to be published).

CONFERENCE & PUBLICATION *Briefs*

SYMPOSIUM ON HEALTH PROBLEMS

Operations research analysts and medical professionals discussed the contribution of operations research to health services of today and tomorrow at a Symposium on Health held at the Bureau on May 14–16, 1969. It was sponsored jointly by the Health Applications Section of the Operations Research Society of America and by the NBS Technical Analysis Division.

General Chairman Charles D. Flagle, of Johns Hopkins University, opened the Symposium, which was greeted on behalf of the Operations Research Society of America by its President, Joseph Engel, of the COMSAT Corporation. Five half-day sessions were held, each devoted to a specific aspect of health services: the role of the consumer, health manpower, the role of technology, hospital care, and organization of health services. These areas had been discussed in the Reports of the two Presidential Advisory Commissions—one on Health Manpower and one on Health Facilities—published during the last 15 months.

Each session was opened by a member of the Commission, who presented the specific challenge of the Commission on the particular problem. Responding to the challenge, a leading operations researcher presented a prepared paper on what operations research can offer to the understanding and solution of the problem.

Two or more discussants were scheduled to comment on each session's two papers, following which comments were invited from the floor. This feature of the sessions often became spirited and in some cases lasted an hour. The sixth half-day session included overviews of the preceding sessions and statements of the role in health services to be played by the Health Applications Section.

The Symposium attracted more than 200 attendees, drawn largely from the ranks of medical professions, operations research, and health administration. It was organized by George K. Chacko of the TRW Systems Group and the program was selected by C. Darwin Stolzenbach of METRO 2000. The *Proceedings* of the Symposium will be published for the registrants; others wishing a copy (at a cost of $10) should communicate with John R. Hall, Secretary, ORSA Health Applications Section, National Center for Health Services Research and Development, 4040 North Fairfax Drive, Rm. 505, Arlington, Va. 22203.

SPACE SIMULATION CONFERENCE

The 5th Annual Space Simulation Conference will be held at the National Bureau of Standards, Gaithersburg, Md., September 14–16, 1970. These conferences are sponsored jointly by ASTM Committee E–21 on Space Simulation, the IES Committee on Solar Planetary Radiation Simulation, and the AIAA Technical Committee on Ground Testing and Simulation, with each of the parent societies in turn assuming the responsibility for organizing and conducting the Conference. ASTM will be responsible for the 1970 meeting, with the assistance of NBS.

The general purpose of the Space Simulation Conference is to provide a forum for presentation of new information on the technology of space simulation. This technology involves the simulation, in the laboratory, of all the environmental features of space, and evaluation of the effects of these simulated environments on materials, components, and systems of satellites and space vehicles. Particular aspects of the space environment to be covered include, but are not limited to, the following, either alone or in combination: high vacuum; solar radiation; charged particle radiation; meteoroid bombardment; zero gravity; acceleration, particularly during blast-off and reentry; magnetic fields; temperature variations; and planetary atmospheres.

Papers are particularly desired in the areas of simulation requirements; simulation facilities; man-rating of simulation facilities; simulation techniques; test methods; behavior of materials, components, systems, and vehicles in simulated environments; correlation of flight test results with laboratory tests; and scaling and modeling.

A more detailed call for papers will be issued in the late summer of 1969.

PAINTS AND PROTECTIVE COATINGS MANUAL

Paints and Protective Coatings, a practical manual recently developed for use by the Departments of the Army, Navy, and Air Force, is now available to the general public.[1] The manual was prepared by the David Litter Laboratories under a contract sponsored by the three military services. NBS acted in an advisory capacity as administrator of the contract.

The manual has general applicability to the civilian sector since it furnishes information on products, prac-

tices, procedures, materials, equipment, and safety measures in the coating of buildings and other permanent structures and facilities. The principal causes of failure of protective coatings are discussed and illustrated by photographs, and specific corrective measures are suggested. Descriptions are given of the operations necessary in painting interior (with a separate chapter on floors) and exterior surfaces of buildings and related facilities, including utility systems, traffic marking, and signs. Attention is given to the application of special coatings such as odorless, vapor-proof, and non-slip finishes, and to the painting of special areas such as "clean" rooms, hot surfaces, swimming pools, dark rooms, glass, plastics, chain fencing, and radioactive areas. Recommended coating systems for a variety of applications are summarized in a series of tables; other tables indicate the Federal specifications relevant to the different products and devices; and there is a glossary of painting terms as well as an index.

Users of this new manual will also be interested in the publication, *Organic Coatings*, issued last year by NBS.[2] Besides presenting practical information on the properties, selection, and use of organic coatings (and certain inorganic coatings), it discusses basic principles in a number of important areas such as polymer structure, coatings formulation, pigment function, use of thinners, coating system compatibility, and theory of corrosion. To quote from the author's Preface, "The information has been selected and presented in a manner that will provide maximum usefulness when the monograph is used as an adjunct to the handbooks and manuals of particular agencies."

STANDARDS LABORATORY CONFERENCE PROCEEDINGS

The *Proceedings of the 1968 Standards Laboratory Conference*[3] (177 pages; $1.50) touches on many important aspects of the management and operation of a measurements laboratory. NBS Special Publication 313, edited by H. L. Mason, includes 50 papers of broad perspective dealing with the conference theme "Making Valuable Measurements."

Some of the topics cover special metrology and calibration problems, management of equipment and data, and the role of international cooperation in making measurements. Other papers discuss the progress of Great Britain and Ireland in adopting the metric system, the Department of Defense's measurement activities, and the work of professional organizations that cooperate with and complement the National Conference of Standards Laboratories.

SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or co-sponsored by NBS and will be held at the Bureau's Gaithersburg, Md., facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. If no other address is given, inquiries should be sent to the person indicated below in care of Special Activities Section, Room A600, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

Government Microcircuit Application Conference (GOMAC). Sept. 16–18. Sponsors: Department of Defense, National Aeronautics and Space Administration, Environmental Science Services Administration, Post Office Department. Contact: R. T. Cook (NBS Office of Technical Information and Publications). **CLASSIFIED.**

Precoordination—The Basis for Industrialized Building. Sept. 24–26. Sponsor: USA Standards Institute Committee A62. Contact: R. W. Smith, Jr. (NBS Building Research Division).

Dental Research—50th Anniversary. Oct. 6–8. Co-sponsor: American Dental Association. Contact: G. R. Dickson (NBS Polymers Division).

American Cybernetics Society. Oct. 14–16. Sponsor: American Cybernetics Society. Contact: Ethel Marden (NBS Center for Computer Sciences and Technology).

3d Materials Research Symposium—Electronic Density of States. Nov. 3–6. Contact: H. C. Burnett (NBS Metallurgy Division).

CURRENT DISLOCATION THEORY ASSESSED AT CONFERENCE

Over 100 representatives from eighteen different countries participated in a conference on the Fundamental Aspects of Dislocation Theory on April 21–25, 1969. Hosted by the NBS Institute for Materials Research at the Bureau's Gaithersburg (Md.) laboratories, the conference brought together active workers in all fundamental aspects of the theory of dislocations to discuss, evaluate, and contribute to the current state of understanding of these defects in materials.

Ten sessions provided a perspective of the current feelings about dislocation theory by asking such questions as "How far have we come?" and "Where do we go from here?"

Two main points stood out in the session chaired by J. D. Eshelby (Sheffield University, England) and R. deWit (NBS) that dealt with current research in "classical dislocation theory," i.e., the theory formulated in terms of linear elasticity over 15 years ago. The first was the concept of the force on a straight but finite discrete dislocation segment, and the second was the advantage of using the elastic Green's function, particularly for anisotropic problems in three dimensions.

A session on lattice theories, conducted by R. Bullough (A.E.R.E., Harwell, England), opened with a survey of the electron theories of cohesion in metals. A knowledge of the cohesive energy of crystal lattices gives a better understanding of the core structure and energy of disloca-

tions, which in turn are essential to understanding the many mechanical and physical properties of dislocations. For practical calculations, the cohesive energy must be able to be represented in a simple spatial form, such as ion pair potentials, or by simple force constant models. The session took up the discussion of the physical validity of the use of ion pair potentials and the use of force constant models, both in the dynamic situation of phonon scattering (flutter) and in the static situation for the harmonic static configurations.

J. Lothe (Oslo University, Norway) chaired a session on the effect of dislocations on phonon interactions that included a review of eigenfrequencies in a dislocated crystal. Fluttering and anharmonic effects, essential components in drag theories, were examined as well. Other papers discussed vibrating string models of dislocations, which could yield experimental information relevant to drag theories.

Two topics, interfaces and disclinations, were covered in Applications of the Geometry of Dislocations, a session chaired by F. R. N. Nabarro (University of Witwatersrand, South Africa). A review of zonal twin dislocations followed an exposition of the theory of dislocations in crystalline interfaces.

Under the chairmanship of J. P. Hirth (Ohio State University), a panel assessed the current status of dislocation theory. The agenda of this panel included core structures in metals, dislocation drag mechanisms, core structure in covalent and polar materials, and equilibrium configurations. It was suggested that in view of recent direct electron microscope observations of core configurations in aluminum, meaningful calculations could now be made on this metal. A new "third neighbor" potential for iron was also presented and discussed.

Field Theories, Parts I and II, were chaired by E. Kröner (Bergakademie Clausthal, Germany) and J. A. Simmons (NBS), respectively. Most of the papers in the first session re-examined the transition from a model of an imperfect crystal lattice to a continuum theory encompassing more detailed and sophisticated defect descriptions than are contained in the classical linear elasticity approach. The session concluded with an attempt to combine the techniques of continuously distributed dislocations with those of engineering plasticity into a model of simple glide in a single crystal.

Two survey papers on dynamical field theories of dislocations opened Part II of Field Theories. The papers dealt separately with general kinematic theories of a geometrical nature and linear elastic field theories. Individual papers were presented in both sessions on such topics as the application of micromorphic mechanics and oriented continua to developing a thermodynamics of the deforming dislocated continuum.

Thermally Activated Processes and Statistical Theories, chaired by A. Seeger (Max-Planck-Institut für Metallforschung, Germany), began with an extensive exposition of the problem of analyzing the effective activation energy for dislocation motion. Later, this session took up the broadening of resonance lines due to the strains arising from random distributions of dislocations. This latter work suggests a possible new experimental technique for probing the dislocation distributions in crystals.

Contributions on electronic properties of dislocations in semiconductors and on electron scattering by dislocations were among those presented in the session on Dislocations—Electron Interactions chaired by R. Thomson (State University of New York, Stony Brook). From the contrasting approaches to electron scattering, it was concluded that final judgment must probably await more careful measurements of low temperature attenuation.

The concluding session covered what the chairman, Professor A. Seeger, called "futurology." In dealing with the future of classical continuum dislocation theory, the need for more detailed descriptions of dislocation arrangements was strongly brought out. The advantage of linear theories over nonlinear theories was pointed out because superposition in linear theories allows one to use averaged quantities. The defense was made, however, for the use of nonlinear continuum theory to treat physical problems where superposition is violated, such as phonon scattering.

It was also agreed that the future holds many possibilities for fruitful interaction between dislocation physics and continuum mechanics and that both approaches should be simultaneously developed. The feeling was expressed that more dislocation physics should be incorporated into the already existing theory of plasticity, so that the engineer would have available a better arsenal of practical theory as well as the know-how to make better materials. On the other hand, a need also exists to develop continuum theories that are internally consistent. Such theories will aid physicists in finding generalizations from microscopic to macroscopic phenomena.

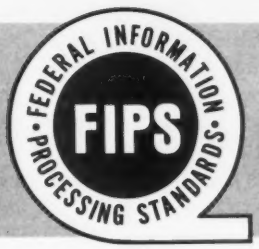
With regard to experimental techniques for measuring microscopic effects, the panel concentrated on the nonlocal ones because of their likely importance in piezoelectric and ionic crystals. Finally, the panel noted that many calculations, such as phonon dispersion, can be carried out in reciprocal space without assuming a two-body potential.

The proceedings, "Fundamental Aspects of Dislocation Theory," including the contributed papers, discussions, and panels, will be published by NBS in early 1970.

[1] This publication, designated as Army TM 5–618, Navfac MO–110, or Air Force AFM 85–3, is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $7.25. Its 225 pages are bound in a rugged, loose-leaf format.

[2] Organic Coatings, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 7 (187 pages, $2.50), by A. G. Roberts. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[3] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.



NOTES

In the fall of 1965 the Secretary of Commerce established the NBS Center for Computer Sciences and Technology to carry out the Secretary's responsibilities under the Brooks Bill (Public Law 89–306, passed October 30, 1965). The Center, under the direction of H. R. J. Grosch, provides leadership and coordination for government efforts in the development of voluntary commercial information processing standards, develops recommendations for Federal information processing standards, performs required research and analysis, and provides scientific and technical support and consultative assistance in the field of computers and information processing to Federal agencies. These Notes will cover information-processing standards activities in the Federal Government, particularly those of the Center.

STANDARD CODE FOR METROPOLITAN STATISTICAL AREAS

The Bureau of the Budget has approved as a Federal Information Processing Standard (FIPS) a Code for the Standard Metropolitan Statistical Areas (SMSA).

Codes and titles for the SMSA's have been published as a Federal General Data Standard, Representations and Codes, by NBS in Federal Information Processing Standards Publication 8 (FIPS PUB 8) entitled *Metropolitan Statistical Areas*[1] (20 cents).

The general concept of an SMSA is one of an integrated economic and social unit with a recognized large population nucleus. For example, the Washington, D.C., Metropolitan Statistical Area is defined to include the District of Columbia, Montgomery and Prince Georges Counties of Maryland, and the following counties and independent cities of Virginia: Alexandria (city), Fairfax (city), Falls Church (city), Arlington (county), Fairfax (county), Loudoun (county), and Prince William (county).

SMSA's were developed to meet the need for the presentation of general-purpose statistics by agencies of the Federal Government. They were established by the Bureau of the Budget (BoB) with the advice of the Federal Committee on SMSA's, which was composed of representatives of the major Federal statistical agencies (BoB, Housing and Home Finance Agency,* U.S. Department of Agriculture, Business and Defense Services Administration, Bureau of Labor Statistics, Bureau of the Census, Bureau of Employment Security, Area Redevelopment Administration, and Federal Reserve System.

*Now a part of the Department of Housing and Urban Development.

Standard definitions of metropolitan statistical areas were issued initially in 1949 as "Standard Metropolitan Areas." They were developed to replace four different sets of definitions then in use for various statistical series—"metropolitan districts," "metropolitan counties," "industrial areas," and "labor market areas." Because of the use of these different definitions, it was not possible to relate statistics on such subjects as population, industrial production, and labor force.

To serve the statistical purposes for which metropolitan areas are defined, their parts must themselves be areas for which statistics are usually or often collected. Thus, each SMSA must contain at least one city of at least 50 000 inhabitants; or two cities having contiguous boundaries and constituting, for general economic and social purposes, a single community with combined population of at least 50 000. For the latter, the smaller city must have a population of at least 15 000. The SMSA will then include the county of such a central city, and adjacent counties that are found to be metropolitan in character, and economically and socially integrated with the county of the central city. The largest city is considered the nucleus and usually gives the name to the area. However, the name in some instances may include other cities in the area. Also, SMSA's may cross state lines.

The definitions of the SMSA's that identify the composition and structure of each area are included in a Bureau of the Budget publication entitled, *Standard Metropolitan Statistical Areas 1967*[1] (30 cents).

FIPS COORDINATING AND ADVISORY COMMITTEE

The NBS Center for Computer Sciences and Technology has established a new Federal Information Processing Standards (FIPS) Coordinating and Advisory Committee to serve as a general advisory group to NBS on Information Processing Standards. The chairmen of the FIPS Task Groups will serve as members of this new Committee, which will coordinate the plans and work of all the FIPS Task Groups. The new committee is chaired by Joseph O.

Harrison, Jr., Chief of the Center's Office of Information Processing Standards (OIPS). Other members represent the Bureau of the Budget, the General Services Administration, and the Interagency Committee on Automatic Data Processing.

The titles, chairmen, and members of the present FIPS Task Groups are:

FIPS Task Group 1—Objectives and Requirements for Standards

Chairman: Harry S. White, Jr. (Commerce-NBS).

Members: Robert M. Brown (Air Force), Charles W. Burlingame (NASA), Garth Burleyson (National Security Agency), Robert G. Cox (HEW), G. Stanley Doore (Commerce-ESSA), James Gillespie (Navy), Philip S. Johnson (Commerce-NBS), Richard W. Lee (NSF), A. J. Matulevich (DoD-Computer Institute), D. L. Shoemaker (GSA), and George W. White (National Communication System).

FIPS Task Group 2—Control Procedures and Header Formats for Remote Terminals

Chairman: Philip S. Johnson (Commerce-NBS).

Members: G. Stanley Doore (Commerce-ESSA), Ann Marie Lamb (BoB), Paul Meissner (Commerce-NBS), John J. Quinn (National Security Agency), Gerald C. Schutz (Transportation), George White (National Communication System), and Paul Simpson (GSA).

FIPS Task Group 3—Subsets, Sign Conventions and Packing Techniques

Chairman: John L. Little (Commerce-NBS).

Members: Robert G. Cox (HEW), Leroy E. Hartswick (VA), Joseph C. Hayes (Navy), Walter A. Magee (BoB), Harold E. McDonough (NSF), and Bruce F. Wellborn (GSA).

FIPS Task Group 5—Federal Information Processing Vocabulary

Chairman: Miss Josephine L. Walkowicz (NBS)

Members: (Not yet selected.)

Federal departments and agencies are being invited to designate members to serve on FIPS Task Group 5 that will review the American Standard Vocabulary for Information Processing and other relevant documents and develop a proposed Federal Information Processing Vocabulary.

FIPS Task Group 4 (chaired by Gerald John, GSA) completed its assignment by recommending Standard Phraseology for Use in RFP's for Requiring Conformity to Federal Information Processing Standards. GSA now is drafting an implementing instruction. FIPS—TG4 has now been dissolved.

The work plans of all of these Task Groups have been reviewed and approved by the Coordinating and Advisory Committee.

Questions regarding the work of the FIPS Coordinating and Advisory Committee may be referred to the secretary of the committee, Howard Gammon, NBS Office of Information Processing Standards, Rm. A268, Instrumentation Bldg., Washington, D.C. 20234 (Tel. 301–921–3545).

The complete text of the promulgating document approved by Center Director H. R. J. Grosch is provided for reference information.

ROLE OF FIPS COORDINATING AND ADVISORY COMMITTEE AND METHOD OF OPERATION OF FIPS TASK GROUPS

A. *Role of FIPS Coordinating and Advisory Committee*

The Center for Computer Sciences and Technology in the National Bureau of Standards in performing its function in developing proposed Federal Information Processing Standards under the Brooks Bill (P.L. 89–206) needs to obtain advice and assistance from other Federal agencies. One way of obtaining this is by means of ad hoc Task Groups formed to review proposed NBS actions and to deal with specific standards problems. The FIPS Coordinating and Advisory Committee will serve as a vehicle for coordinating the work assignments to such FIPS Task Groups, and as a general advisory group to NBS on Information Processing Standards.

The FIPS Coordinating and Advisory Committee will consist of (1) the Chief of Office of Information Processing Standards, Center for Computer Sciences and Technology, NBS, as Chairman, (2) the Chairman of the FIPS Task Groups, (3) the Chairman of the Interagency ADP Committee, and (4) such other members as the Chairman of the FIPS Coordinating and Advisory Committee may designate. The composition of the Committee will also include members from NBS, BoB, and GSA, the three agencies principally responsible for carrying out the provisions of the Brooks Bill.

B. *Purpose of Task Groups*

NBS recognizes that it must coordinate its Standards Program on an interagency basis. It is the purpose of FIPS Task Groups to assist NBS to provide better coordination of the Federal ADP standards program. Technical personnel with a knowledge of each agency's requirements can assist NBS in matters regarding development, adoption, and implementation of the standards.

This participation by agencies will enable NBS to gain greater insight into their respective agency problems and requirements. Such participation also allows NBS to more effectively evaluate its own standards program, and focus efforts on Agency needs.

C. *Specific Role of Task Groups*

The National Bureau of Standards is charged under the Brooks Bill (P.L. 89–306) with recommending uniform Federal ADP standards through the Secretary of Commerce and the Bureau of the Budget to the President of the United States. This responsibility requires detailed coordination with and advice from Federal departments and agencies regarding their ADP operations and objectives. FIPS Task Groups will be organized on a selective basis for such purposes as: (1) providing advice to NBS on specific draft proposals in the standards area, (2) making recommendations on specific problems, and (3) developing draft proposals in specified standards problem areas, as assigned in work scope statements.

D. *Initiation of Task Groups*

Four Task Groups have already been established to deal with (1) Definition of Federal Information Processing Standards Objectives and Requirements, (2) Recommendations on Standard Control Procedures and Header Formats for Remote Computer Terminals, (3) Recommendations on ASCII Character Subsets, Algebraic Sign Conventions, and Packing Techniques, and (4) Preparation of Subsections for Uniform Implementation of Approved Federal ADP Standards for Inclusion in Requests for Proposals.

The need for any additional Task Groups will be considered by the FIPS Coordinating and Advisory Committee. Such additional FIPS Task Groups will be formed, as required, by NBS. For each new Task Group, NBS will inform the Interagency ADP Committee of the scope of work proposed and invite participation of appropriately qualified technical representatives. In addition, NBS will send a letter to appropriate department heads (selected in accordance with the nature of the specific problem) to request qualified participants.

E. *Approval of Task Group Work Programs*

In order to ensure a system approach and to avoid duplication of efforts, task group work assignment statements must be coordinated. Therefore, such work statements will be reviewed by the FIPS Coordinating and Advisory Committee and approved by NBS. Specifically, the Coordinating and Advisory Committee will review the initial statement of scope and broad program of work for each FIPS Task Group; and subsequently request each Task Group to develop detailed work plans with target dates for completion of subtasks and the work assignment as a whole. Subsequent revised work statements and completion dates would then be subject to review and approval as above. Task Groups that are unable to complete their assigned tasks by the scheduled dates should notify the Coordinating Committee as soon as foreseen, giving the reasons therefor.

F. *Internal Operation of Task Groups*

Each Task Group's effort will be directed toward accomplishing the tasks in its approved work statement. A task will normally be to review a proposed recommendation or directive concerned with Federal Information Processing Standards. On occasion, however, a task may consist of developing a draft proposed standard in a particular area. In any event, the final product will be a recommendation to NBS via the FIPS Coordinating and Advisory Committee as outlined in H below.

In conducting the business of the Task Group, the keeping of formal minutes and other associated documents should be minimized consistent with the accomplishment of the Task Group's work.

When a consensus cannot be reached by a Task Group on a particular matter, the majority view will form the basis of the recommendation. However, minority positions will accompany the recommendation forwarded to the FIPS Coordinating and Advisory Committee.

G. *Life of Each Task Group*

Upon the completion of all of its assigned tasks, a Task Group will be dissolved by NBS on the advice of the Coordinating and Advisory Committee.

H. *Transmittal of Task Group Recommendations*

Task Group recommendations will be transmitted to the Secretary of the FIPS Coordinating and Advisory Committee for the Committee's review and comments. Recommendations of FIPS Task Groups, with the comments of the FIPS Coordinating and Advisory Committee, will be considered as advice to NBS. The Chairman of FIPS Coordinating and Advisory Committee in his dual role as Chief of the Office of Information Processing Standards will receive the recommendations as advice to NBS.

The Chairman of the Interagency ADP Committee (as a member of the FIPS Coordinating and Advisory Committee) will inform the membership of the Interagency ADP Committee as appropriate about the work of the FIPS Task Groups.

I. *Extent to Which Task Group Members Represent Their Agencies*

Members of FIPS Task Groups will participate as qualified experts having knowledge of their agencies' interests in the subject under study. The FIPS Task Groups will not, however, replace the formal solicitation by NBS of agency comments on proposed Federal standards (as outlined in BoB Guidance Letter to the Secretary of Commerce dated December 15, 1966). Accordingly, each agency is not bound by the individual views of its Task Group representative.

STATUS OF FEDERAL INFORMATION PROCESSING STANDARDS RECOMMENDATIONS

First Phase: PROJECT NOMINATION
- Signaling Speeds for Data Transmission (X3.1-1962)
- Specifications for General Purpose Paper Cards for Information Processing (X3.11-1966)
- Parallel Signaling Speeds for Data Transmission (X3.13-1966)
- Time Sharing and Remote Console Considerations
- Hardware Interfaces
- Keyboard Configuration
- Synchronous Signaling Speeds
- Numerical Machine Control Perforated Tape

Second Phase: STANDARDS DEVELOPMENT
- Vocabulary for Information Processing (X3.12-1966)
- Interchangeable Magnetic Disk Media
- RFP, RFQ, and Contract Formats
- OCR Measurement Technology
- OCR Paper
- ADP Systems Site Preparation
- Magnetic Tape Labels for Information Interchange
- Hollerith Punched Card Code (X3.26-1969)
- FORTRAN Standard Reference (X3.9–1966, X3.10–1966)
- COBOL Programming Language (X3.23-1968)
- Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI) (X3.14-1969)
- Character Sets for OCR Input (X3.17-1966)
- Layout of Forms for OCR Input
- Bit Sequencing of the USA Standard Code for Information Interchange in Serial-by-Bit Data Transmission (X3.15-1966)
- Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the USA Standard Code for Information Interchange (X3.16-1966)
- Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission (X3.24-1966)
- Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication (X3.25-1968)
- One-Inch Perforated Paper Tape for Information Interchange (X3.18-1967)
- Rectangular Holes in Twelve-Row Punched Cards (X3.21-1967)
- Take-Up Reels for One-Inch Perforated Paper Tape (X3.20-1967)

Third Phase: RECOMMENDATION FOR ADOPTION
- None

Fourth Phase: ISSUED FEDERAL INFORMATION PROCESSING STANDARDS
- FIPS PUB 1 Code for Information Interchange (X3.4-1968)
- FIPS PUB 2 Perforated Tape Code for Information Interchange (X3.6-1965)
- FIPS PUB 3 Recorded Magnetic Tape for Information Interchange (X3.22-1967)
- FIPS PUB 4 Calendar Date
- FIPS PUB 5 States of the United States
- FIPS PUB 6 Counties of the States of the United States
- FIPS PUB 7 Implementation of Code for Information Interchange and Related Media Standards
- FIPS PUB 8 Metropolitan Standard Areas
- NBS Reference-Magnetic Computer Tape Amplitude

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

NSRDS NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

Superconductive Materials

NBS Technical Note 482, *Superconductive Materials and Some of Their Properties*[1] ($1.25), by B. W. Roberts, General Electric Research and Development Center, Schenectady, N.Y., is a noncritical compilation of data on superconductive materials that has been extracted from a portion of the literature published up to early 1968. This publication extends the data previously published in NBS Tech. Note 402, September 1966. The properties concerned are composition, critical temperature, critical magnetic field, crystallographic data, and lowest temperature tested for superconductivity.

The compilation consists of three major tables. Table 1 lists the elements and some of their superconductive properties. The data have been selected generally from recent studies whose authors appear to have given serious consideration to sample purity and perfection. Table 2 contains reported data on superconductive materials plus all materials that have been tested specifically for superconductivity down to some temperature T_n without discovery of a transition. Because superconductive properties vary with purity and other metallurgical aspects, the author has recommended that the appropriate literature be checked to determine the most probable critical temperature or critical field of a given alloy. Table 3 presents data on those materials exhibiting superconductivity in a high magnetic field.

Technical Note 482 also includes review articles concerned primarily with the experimental and material aspects of superconductivity, a bibliography, and a complete alphabetical cross-index to authors by reference number.

FORTRAN Programs on Magnetic Tape

Among recent publications of the Office of Standard Reference Data, two have been devoted to descriptions of a number of general-purpose computer programs for file manipulation, text editing, and data retrieval. Announcements of these reports appeared in *NSRDS News*[2, 3] and have stimulated sufficient demand for the program decks to warrant the release of a magnetic tape through the Clearinghouse for Federal Scientific and Technical Information. The price of this tape is $100, and it is identified by the CFSTI Number PB-183142.[4] The price of this tape represents a very small fraction of what it would cost to keypunch the programs (in excess of 2500 cards) from the published reports.

The tape contains blocked card images of program decks for a series of general-purpose computer programs for data and file manipulation, text editing, and data retrieval. The programs, developed by the staff of the Data Systems Design Group of the Office of Standard Reference Data, are written in as neutral a dialect of FORTRAN as possible so that they can be run with little or no modification on any computer having a FORTRAN compiler. The tape consists of two files of records of 720 characters each. Each record consists of nine 80-column card images. The first field of 37 records contains the REFORM program as listed and described in *REFORM: A General-Purpose Program for Manipulating Formatted Data Files*[1] (40 cents), in NBS Tech. Note 444, by R. C. McClenon and J. Hilsenrath. The REFORM program makes it possible to manipulate files containing as many as nine different card formats. It can select or abridge information from any of the cards and print that information or reformat cards in any desired order of arrangement. Provision is made for introducing as many as 26 arbitrary strings of characters each of which may be up to 79 characters in length, thereby permitting the insertion of labels, headings, or comments into the file.

The second file of 248 records contains a number of programs as listed and described in *EDPAC: Utility Programs for Computer-Assisted Editing, Copy-Production, and Data Retrieval*[1] (70 cents), NBS Tech. Note 470, by C. G. Messina and J. Hilsenrath. EDPAC is a package of five related utility computer programs: SCRAMBLE, SUBSTITUTE, SEARCH, BLOCKSEARCH, and JUSTIFY. SCRAMBLE scans an imput file for specified characters that it replaces by different characters. SUBSTITUTE similarly replaces strings of characters with

other strings. SEARCH and BLOCKSEARCH scan for the occurrence of certain strings and list the lines or blocks, respectively, in which they occur. JUSTIFY produces right-hand justified text for printing on a card-controlled typewriter or on an extended character line printer.

Rate Constants of Selected Reactions

A Review of Rate Constants of Selected Reactions of Interest in Re-Entry Flow Fields in the Atmosphere[1] (60 cents), NBS Tech. Note 484, by M. H. Bortner, General Electric, Schenectady, N.Y., is a study supported by the Defense Department's Advanced Research Project Agency under Project DEFENDER.

During the past several years, a concentrated effort has been made to obtain the chemical kinetic data needed for flow field calculations. The present study is an effort to review such data in detail and provide a set of data that would be helpful for making flow field calculations. The major reactions normally encountered in flow field re-entry calculations for the oxygen-nitrogen system are reviewed in Technical Note 484, and a rate constant value for each reaction is recommended. Collisional ionization processes, charge exchange reactions, and attachment-detachment reactions are included. Rate constant coefficients to fit the equation $k=aT^b\ e^{-c/T}$ are reported in tabular form for the selected rate constant. The data are also graphed as log k vs T(K). In all, over 20 forward and reverse reactions are reviewed, and 122 references are included.

Neutron Data File

In December 1966, the Brookhaven National Laboratory (BNL) and the ENEA Neutron Data Compilation Centre (CCDN) published an index to the BNL/CCDN computerized file on neutron data as CCDN-NW/4. This has now been revised and brought up to date, describing the content of the data file as of March 1969. The revised index is CCDN-NW/8 and is published as Newsletter No. 8 from the ENEA Neutron Data Compilation Data Centre. Data references in the present list are available within the ENEA region on request to the ENEA Neutron Data Compilation Centre, Gif-sur-Yvette, France. These requests can be formulated as a general demand for all data on a nuclide, data on a certain reaction type for a set of nuclides, or in terms of available retrieval parameters—nuclide, quantity, energy range, laboratory, and reference. The output can be given in listings or in computer media, preferably magnetic tape, and in additional graph-plots of cross section data.

The output formats available are related to the Sigma Center Information Storage and Retrieval Systems of the Brookhaven National Laboratory (SCISRS I Format) and allow for compatibility with the CCDN system. Data requests from Canada and the U.S.A. should be directed to the National Neutron Cross Section Data Center, Brookhaven National Laboratory, Upton, Long Island, N.Y. 11973. Data requests for other participating OECD (Organization for Economic Co-operation and Development) countries should be directed to: CCDN, B.P. 9, 91 Gif-sur-Yvette, France. Data requests from Russia should be directed to: Informazionnyi Zentr po Yadernym Dannym, Obninsk (Kaluga region), U.S.S.R. Data requests from the rest of the world should be directed to: Nuclear Data Unit, International Atomic Energy Agency, Kaerntnerring 11, Vienna 1, Austria.

Recent Gmelin Handbooks

The *Gmelin Handbooks*, published by the Gmelin Institute, Frankfurt, Germany,[5] provide exhaustive encyclopaedic data and information on elements and their compounds. Since 1968 several new volumes have been issued. Because users of data on physical properties of substances may be interested in the information they contain, brief descriptions of these handbooks are provided.

Nickel C 1 contains nickel coordination compounds beginning with Ni^0 and Ni^I and Ni^{II}, including the compounds with ammonia, organic amines, organic pyridine and derivatives and other heterocyclic ligands with N, O, and S as hetero atoms. *Nickel C 2* contains compounds with ligands like acetylacetone, Schiff bases, oximes, and sulfur- and phosphorus-containing compounds. These two Nickel volumes describe 6600 single inorganic compounds on 1245 pages covering the literature to 1967.

Nickel A II 2 is devoted to the electrochemistry of nickel and contains information on Ni storage batteries and on the electrodeposition of Ni.

Chlorine A supplements the 1927 published volume on this element. In 396 pages it contains information on the technology of chlorine and its compounds and provides data on physical properties.

Chlorine B 1 provides data on chlorine compounds and deals especially with the hydrogen-chlorine reaction and with gaseous HCl, its properties and reactions. It also includes information on the HCl-H_2O system and aqueous HCl.

Two volumes on carbon, *Carbon B 2* and *Carbon B 3*, give complete descriptions of: graphite; the technology of natural and synthetic graphite; and the physical properties of graphite—especially crystallographic, mechanical, thermal, electric, magnetic, and optical. Special emphasis is given to interfacial phenomena—wetting and adsorption. Data on the graphite compounds—oxides, halides, and metal compounds—are included as well as information on colloidal carbon and carbon black.

Vanadium A 2 is the second volume on this element. It contains data on its isotope properties, properties of the atom and atomic ions, and the physical properties of the solid element, as well as electrochemical behavior and chemical reactions of the solid metal and of ions. Information on valence, transition reactions, and analytical detection and determination is also included.

Mercury B 3 is the third volume devoted to Hg compounds, including compounds with S, Se, Te, the carbon-

ates, cyanides, thiocyanides, acetates, etc. *Mercury B 4* will conclude the mercury compounds and will include an index of compounds and properties.

Oxygen 8, the last of the oxygen volumes, provides a treatment of oxygen-containing radicals and of higher hydroxyperoxides. This volume also contains an alphabetic subject index as well as a formula index on the oxygen compounds contained in these eight volumes.

Persons in the United States may obtain further information on the Gmelin Handbooks from the United States Office of The Gmelin Institute, 7 Woodland Ave., Larchmont, N.Y. 10538. Others should write to Gmelin-Institut, 6 Frankfurt Am Main, Germany.

CORRECTION

As printed in the April 1969 issue of NSRDS News, the item on the Russian publication *Thermophysical Characteristics of Substances* inadvertently stated that the contents, rather than the table of contents, had been translated. This publication is in the process of being translated and it is too early to know when it will be completed. When the translation is available, details will be announced in this column.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.
[2] NSRDS News, Nat. Bur. Stand. (U.S.), Tech. News Bull. **51**, No. 12, 274–276 (Dec. 1967).
[3] NSRDS News, Nat. Bur. Stand. (U.S.), Tech. News Bull. **53**, No. 1, 10–11 (Jan. 1969).
[4] Available from the Clearinghouse for Federal Scientific and Technical Information, NBS, U.S. Department of Commerce, Springfield, Va. 22151, for the price indicated.
[5] NSRDS News, Nat. Bur. Stand. (U.S.), Tech. News Bull. **52**, No. 12, 268–270 (Dec. 1968).

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume 53, No. 7, July 1969, 30 cents. Annual subscription: Domestic, $3; foreign, $4. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75. Single copy price varies.
Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25.
Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25.

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